MINIMUM STANDARD 3.07

EXTENDED-DETENTION BASIN & *ENHANCED* EXTENDED-DETENTION BASIN

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MINIMUM STANDARD 3.07

EXTENDED-DETENTION BASIN & *ENHANCED* EXTENDED-DETENTION BASIN

Definition

An extended-detention basin is an impoundment that temporarily stores runoff for a specified period and discharges it through a hydraulic outlet structure to a downstream conveyance system. An extended-detention basin is usually dry during non-rainfall periods.

Purpose

An extended-detention basin can be designed to provide for one, or all, of the following: a) *water quality enhancement*, b) *downstream flood control*, and c) *channel erosion control*.

Water Quality Enhancement

An **extended-detention basin** improves the quality of stormwater runoff through gravitational settling. However, due to frequent high inflow velocities, settled pollutants often get resuspended.

An ***enhanced*** **extended-detention basin** has a higher efficiency than an extended-detention basin because it incorporates a shallow marsh in its bottom. The shallow marsh provides additional pollutant removal through *wetland plant uptake*, *absorption*, *physical filtration*, and *decomposition*. The shallow marsh vegetation also helps to reduce the resuspension of settled pollutants by trapping them.

The target pollutant removal efficiencies for both extended-detention and *enhanced* extended-detention basins are presented in **Table 3.07-1**. The target pollutant removal efficiencies are based on certain design criteria associated with the physical characteristics of the basin, and shallow marsh, when used.

FIGURE 3.07 - 1a
Extended-Detention Basin - Plan

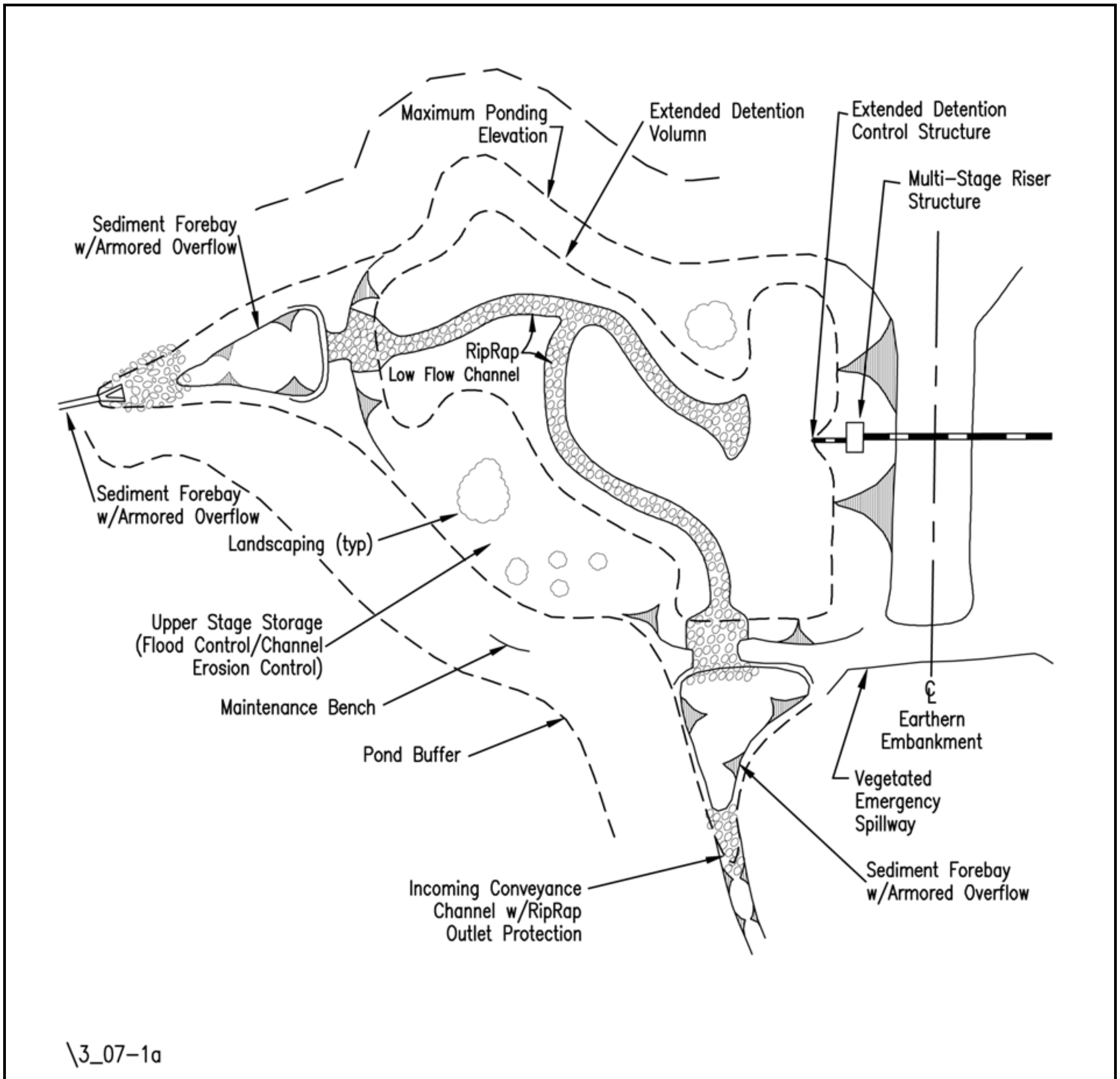
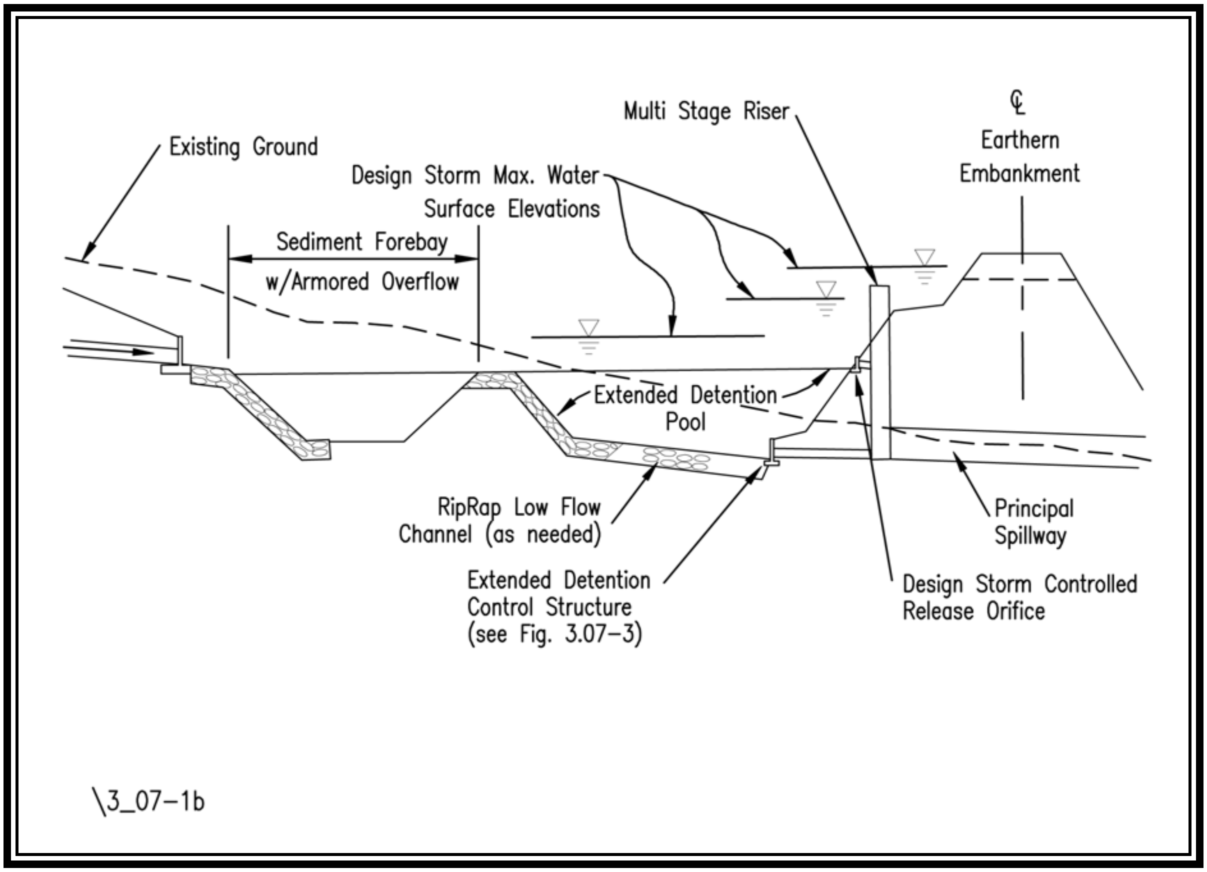


FIGURE 3.07-1b
Extended-Detention Basin - Section

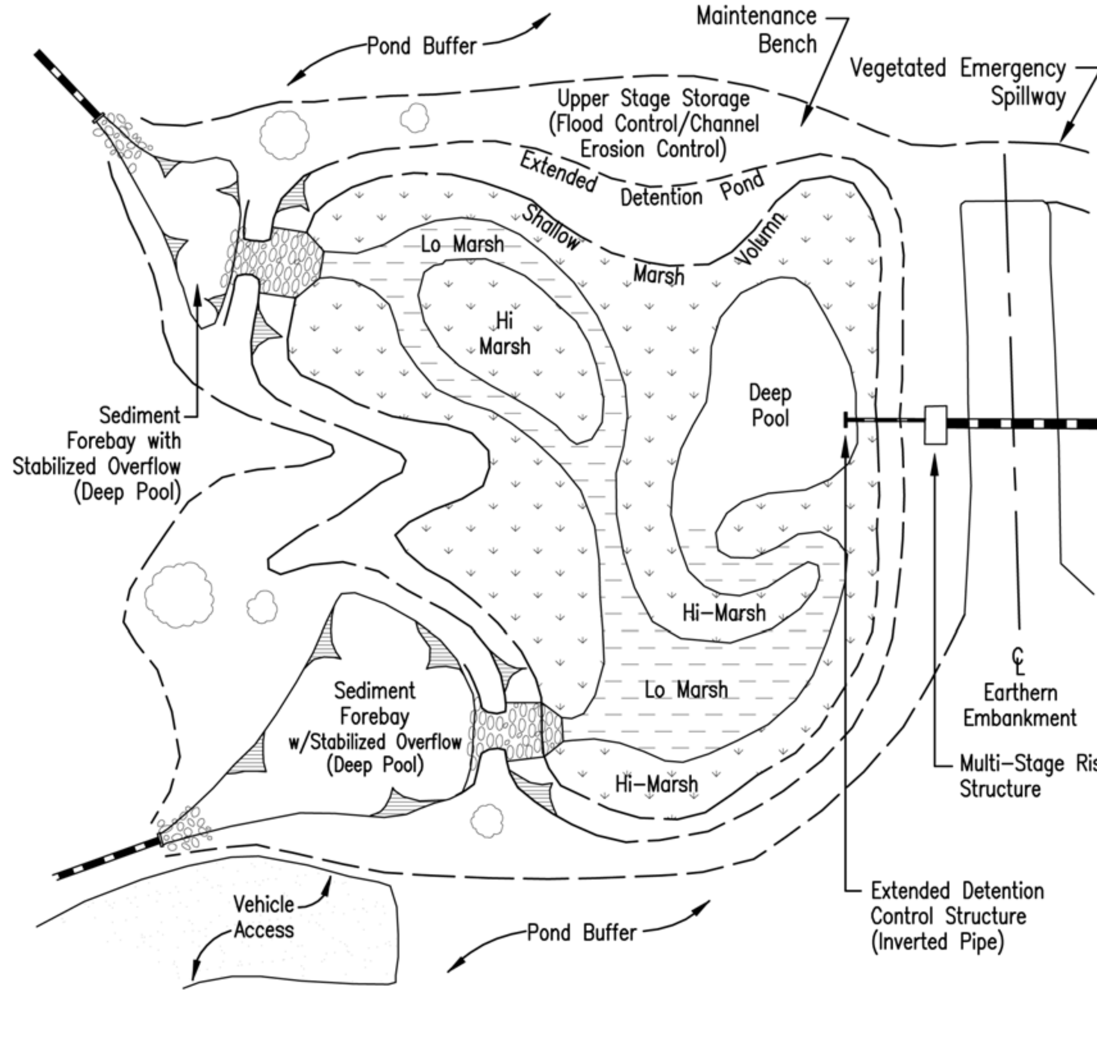


<u>Flood Control</u>

Extended-detention basins can be designed for flood control by providing additional storage above the extended-detention volume, and by reducing the peak rate of runoff from the drainage area. The design storms chosen for flood control are usually specified by ordinance, or are based on specific watershed conditions. By managing multiple storms, such as the 2- and 10-year storms, adequate flood control may be provided for a broad range of storm events.

The additional volume required for storage above the extended-detention volume can be readily determined using the hydrologic methods discussed in **Chapter 4, Hydrologic Methods**. Once this volume is known, a control or spillway structure can be designed and the reservoir routing and channel capacity design techniques discussed in **Chapter 5, Engineering Calculations**.

FIGURE 3.07 - 2a
Enhanced Extended-Detention Basin - Plan



Depth Zone	% of Surface Areas
Deep Pool	20%
Lo Marsh	35%
Hi Marsh	45%

FIGURE 3.07 - 2b
Enhanced Extended-Detention Basin - Section

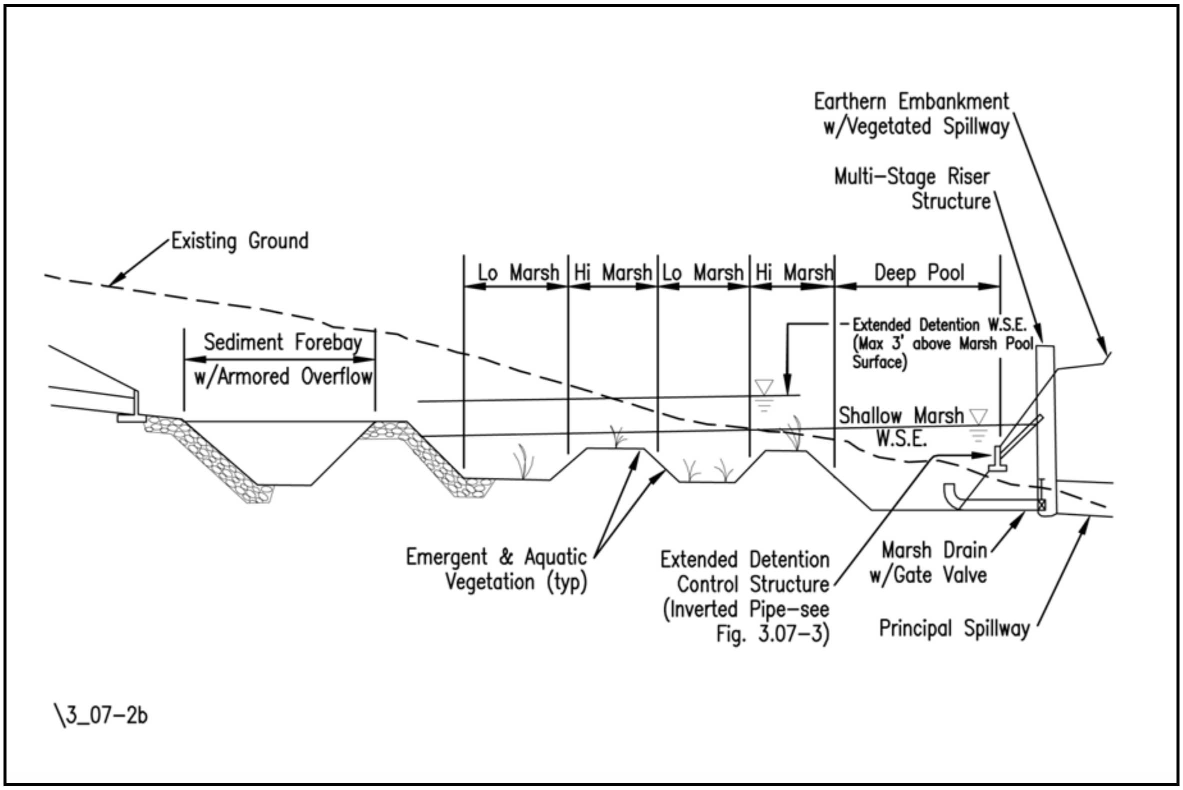


TABLE 3.07 - 1
Pollutant Removal Efficiencies for
Extended-Detention & Enhanced Extended-Detention Basins

Type	Target Phosphorus Removal Efficiency	Impervious Cover
Extended-detention (30 *hr*. Drawdown of 2 × WQ Volume)	35%	22 - 37%
Enhanced extended-detention (30-*hr*. Drawdown of 1 × WQ Volume, and 1 × WQ Volume Shallow Marsh)	50%	38 - 66%

Channel Erosion Control

The objective in controlling channel erosion is to reduce the rate of discharge from a designated frequency storm to below the critical velocity of the downstream channel. The critical velocity of a channel is the velocity that, when exceeded, causes the channel bed or banks to erode. The Virginia Erosion and Sediment Control Handbook, 1992 edition, provides the theoretical critical velocities for various natural channel linings. This critical velocity approach, however, does not consider the frequency or the duration of the critical velocity flow. An increase in impervious cover will increase the frequency of occurance of the "pre-developed" design storm discharge by raising the rainfall to runoff response characteristics of the drainage area. A detention basin will increase the duration of the "pre-developed" design storm discharge by releasing the runoff over time. (A detention basin lowers the peak by spreading it out over a longer period of time.) An extended-detention basin, on the other hand, reduces the discharge based on an extended period of time rather than a peak rate of discharge. Extended-detention of a specific design storm will typically result in lower rates of discharge than the "pre-developed" rate (or critical velocity), thereby compensating for the effects of increased frequency and duration.

The selection of an design storm and a extended-detention period is not a scientific process and is currently determined to be the runoff from the 1-year frequency storm, detained and released over a 24 hour period. Studies show a significant reduction in stream channel erosion below extended-detention facilities designed to this criteria (Galli MWCOG, 1992). Extended-detention of the 1-year storm lowers the discharge velocities from a broad range of storm frequencies to non-erosive levels.

Conditions Where Practice Applies

Drainage Area

The **minimum** contributing drainage area for an extended-detention basin varies with the required extended-detention volume and draw down period and the resulting orifice size. The orifice configuration for small drainage areas should be selected carefully since small openings (less than 3 inches) are prone to clogging. Several different configurations for effective trash, debris, and sediment control are presented in **Figure 3.07-3**. The engineer is free to choose any of these, or to select from other innovative designs.

The **maximum** drainage area served by an extended-detention basin will vary from watershed to watershed. Drainage areas above 50 to 75 acres may require provisions for *base flow*. (Refer to **Design Criteria**). Care should be taken when sizing the water quality orifice if base flow is present.

An undersized orifice may create an undersized permanent pool within the extended-detention volume, leaving inadequate volume above it to provide the required extended-detention. An oversized orifice will result in little extended-detention of the water quality volume.

Development Conditions

Lacking a permanent pool of water, a detention facility is rarely considered aesthetically pleasing. It is, therefore, recommended for *low-visibility* sites. In certain situations, an extended-detention basin may be used on a *high-visibility* site, but the designer must be careful to avoid stagnation or excessive infiltration of the shallow marsh. Maintenance of the basin's shallow marsh is not necessarily critical to its ability to remove pollution, but maintenance **is critical** to ensure the BMP's acceptance by adjacent landowners.

Extended-detention basins can be used for low- to medium-density residential or commercial projects, as classified by their impervious cover. (see **Table 3.07-1**). Along with the storage and shallow marsh volumes required in the basin, a minimum 20-foot vegetated buffer should also be provided. This requirement results in the need for more land. It is for this reason that the use of extended-detention basins may not be the best choice of water quality BMP in developing watersheds where land is at a premium. This strengthens the argument for a regional or watershed approach to stormwater management. A regional extended-detention basin is not only more cost-effective, but is also more likely to be installed on land that is not suitable for development. (It should be noted, however,that the environmental impacts and appropriate permits must still be considered for such an application.)

FIGURE 3.07 - 3a
Trash and Debris Rack Configurations for Extended-Detention Control Structures

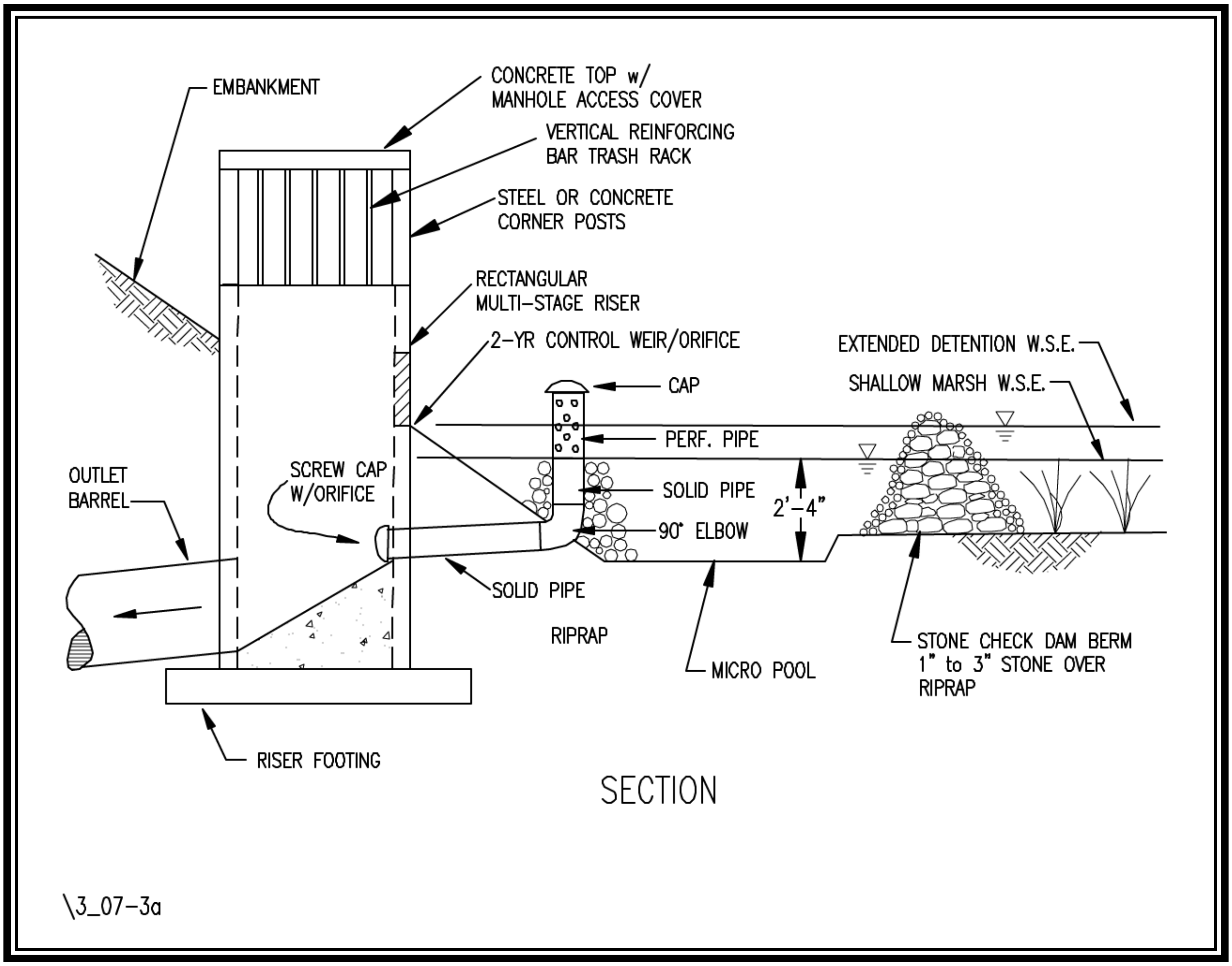


FIGURE 3.07 - 3b

Trash and Debris Rack Configurations for Extended-Detention Control Structures

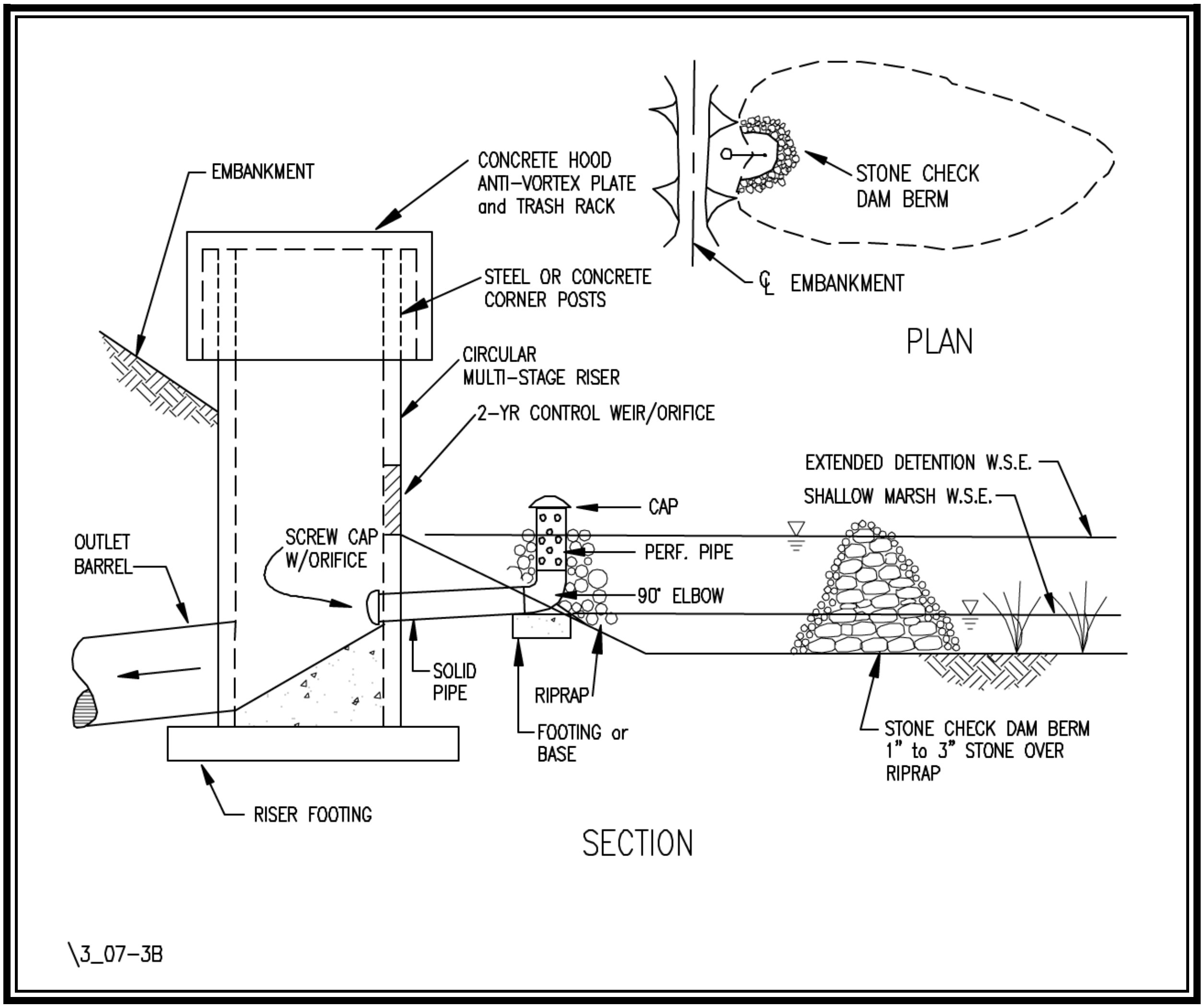
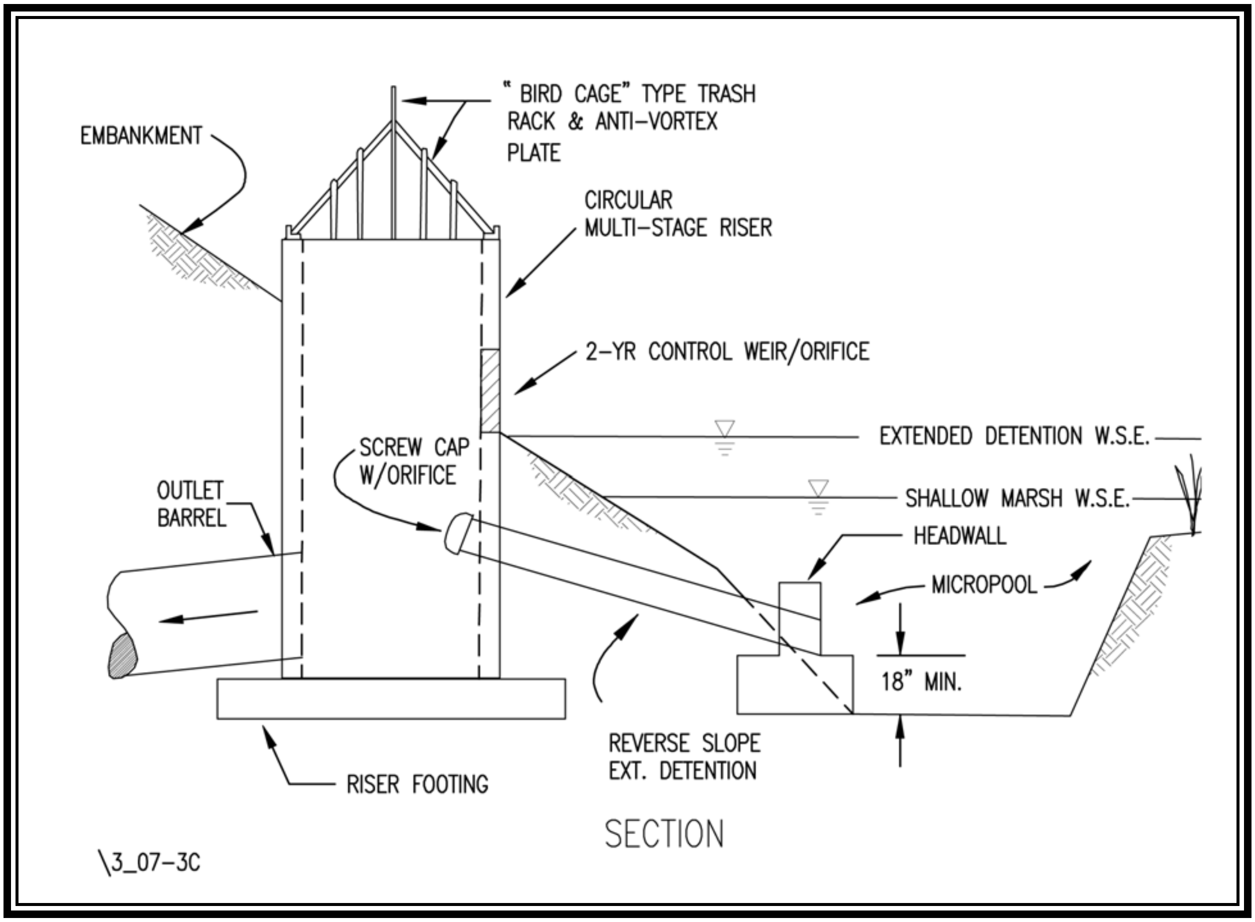


FIGURE 3.07 - 3c
Trash and Debris Rack Configurations for Extended-Detention Control Structures



Planning Considerations

The success of an extended-detention basin is dependent on the designer's ability to identify any site and downstream conditions that may affect the design and function of the basin. Above all, the facility should be compatible with both upstream and downstream stormwater systems to promote a *watershed approach* in providing stormwater management.

The planning considerations for designing the shallow marsh of an *enhanced* extended-detention basin are very similar to those of a constructed wetland (refer to **Minimum Standard 3.09, Constructed Stormwater Wetland; Planning Considerations**).

<u>Site conditions</u>

Existing site conditions should be considered in the design and location of an extended-detention basin. Features such as topography, wetlands, structures, utilities, property lines, easements, etc., may impose constraints on the development. Local government land use and zoning ordinances may also specify certain requirements.

All extended-detention basins should be a minimum of 20 feet from any structure or property line, and 100 feet from any septic tank/drainfield. Extended-detention basins should also be a minimum of 50 feet from any steep slope (greater than 15%). Otherwise, a geotechnical report will be required to address the potential impact of any basin that must be constructed on or near such a slope.

Additional considerations are as follows:

1. **Soils –**

   In the past, many designs were accepted based upon soils information compiled from available data, such as SCS soil surveys. While such a source may be appropriate for a pre-engineering feasibility study, final design and acceptance **should be based on an actual subsurface analysis and a permeability test**, accompanied by appropriate engineering recommendations. The references listed at the end of this standard and at the end of **Minimum Standard 3.10, Infiltration Practices** provide more detailed information regarding the feasibility analysis of subsurface conditions for various soil types. Due to its complexity, this topic is not covered here.

   Highly permeable soils are not suited for extended-detention basins. A basin with highly permeable soils will act as an infiltration facility until the soils become clogged. Although this phenomenon is not always considered a negative impact, it does change the function and design of the basin. For an *enhanced* extended-detention basin, the soils must support the shallow marsh **at the time of stabilization and planting**.

A thorough analysis of the soil strata should be conducted to verify its suitability for use with an extended-detention basin. The geotechnical study required for the embankment design (refer to **Minimum Standard 3.01, Earthen Embankment**) will often provide adequate data for this purpose. The soil permeability may be such that the basin can support a shallow marsh. However, as the depth of the temporary storage increases, the increased head or pressure on the soil may increase the rate of infiltration. If necessary, a liner of clay, geosynthetic fabric, or other suitable material may be used in the basin (as specified by a geotechnical engineer). Refer to the design criteria for basin liners.

2. **Rock –**

The subsurface investigation should also identify the presence of rock or bedrock. Excavation of rock may be too expensive or difficult with conventional earth moving equipment.Blasting the rock for removal may be possible, but it may also open seams or create cracks in the underlying rock, resulting in an unwanted drawdown of the shallow marsh. Blasting of rock is not recommended unless a liner, as described above, is used.

3. **Karst –**

In regions where Karst topography is prevalent, projects may require thorough soils investigation and specialized design and construction techniques. Since the presence of karst may affect BMP selection, design, and cost, a site should be evaluated **<u>during the planning phase of the project</u>**.

4. **Existing Utilities –**

Most utility companies will not allow a permanent or temporary pool to be installed over their underground lines or right-of-ways. If such a site must be used, the designer should obtain permission from the utility company **before designing the basin**. The relocation of any existing utilities should be researched and the costs included in the overall basin cost estimate.

Environmental Impacts

1. **Wetlands–**

Large facilities and/or regional facilities lend themselves to being placed in low lying, and usually environmentally sensitive, areas. Such locations often contain wetlands, shallow marshes, perennial streams, wildlife habitat, etc., and may be protected by state or federal laws. The owner or designer should investigate the regional wetland maps and contact appropriate local, state, and federal agencies to verify the presence of wetlands, their protected status, and the suitability for an extended-detention basin at the location in question.

With careful planning, it may be possible to incorporate wetland mitigation into an extended-detention basin design. This assumes that the functional value of the existing or impacted wetland can be identified and included, reconstructed, or mitigated for, in the basin. Contact the Virginia Department of Environmental Quality for more information regarding wetland mitigation.

2. **Downstream Impacts–**

Urban detention and retention basin design should be coordinated with a watershed or regional plan for managing stormwater runoff, if available. In a localized situation, an individual basin can provide effective protection for the downstream channel if no other areas contribute runoff in a detrimental way to the channel. However, an uncontrolled increase in the number of impoundments within a watershed can severely alter natural flow conditions, causing combined flow peaks or increased flow duration. This can ultimately lead to flooding downstream degradation.

3. **Upstream Impacts–**

The upstream channel must also be considered, especially when the extended-detention basin is used to control downstream channel erosion. Erosive upstream flows will not only degrade the upstream channel, but will also significantly increase the maintenance requirements in the basin by depositing large amounts of sediment eroded from the channel bottom.

Water Quality Enhancement

In an extended-detention basin, the quality of the incoming stormwater is improved through *gravitational settling* of pollutants from the water quality volume. The pollutant removal efficiency for *soluble* pollutants is usually much **lower** than for *particulate pollutants*. Therefore, the efficiency of an extended-detention basin can be **enhanced** by adding a *shallow marsh* to the lower stage of the basin. The shallow marsh creates physical and biological characteristics that are more conducive to the removal process for soluble pollutants.

Settling column studies suggest a maximum upper limit of approximately 40 to 50% removal for total phosphorous after 48 hours, with most of the removal occurring within the first 6 to 12 hours (MWCOG, 1987). However, field studies show a much broader range in removing phosphorous (15-70%) and in removing sediment (65%). Since the soluble form of phosphorous comprises nearly half the phosphorous found in urban runoff, the lower efficiency of 35% (**Table 3.07-1**) is deemed appropriate. The increase in efficiency of *enhanced* extended-detention is attributed to the ability of the shallow marsh to reduce the soluble pollutant levels.

Providing a larger extended-detention volume (similar to providing a larger permanent pool for a retention basin) may not increase the pollutant removal efficiency. **Increasing the volume without increasing the detention time results in a larger orifice size and, therefore, less control of the smaller "first flush" storms**. Simply increasing the detention time will not provide additional efficiency either, since the 30-hour drawdown period exceeds the *probable settling time* associated with most particulate pollutants.

The pollutant removal efficiency in an *enhanced* extended-detention basin **can** be increased, however, by enlarging the volume of the shallow marsh. As the volume of the marsh is increased, with respect to the contributing drainage area, the *hydraulic residence time* is increased. This longer residence time provides more opportunity for further biological uptake and decomposition of pollutants.

Flooding and Channel Erosion Control

Flood control and downstream channel erosion are managed by storing additional runoff above the extended-detention pool (and shallow marsh) and by properly sizing the discharge opening in the riser structure.

When selecting an extended-detention basin, the biggest concern is how much land it requires. The storage volume needed above the extended-detention pool (and shallow marsh) must be approximated and its availability verified on the preliminary site plan.

> *A preliminary sizing estimate is recommended* ***during the planning stage*** *to verify the feasibility of using an extended-detention basin. (See* ***Chapter 5, Engineering Calculations*** *for Storage Volume Requirement Estimates).*

Sediment Control

An extended-detention basin may be used as a *temporary sediment control basin* during construction. The design of a temporary sediment basin is based on the *maximum drainage area* and *rate of runoff* expected anytime during the site construction process. In contrast, the design of the permanent stormwater basin is based on *post-developed land use conditions*. When designing a basin to provide both temporary sediment control and permanent stormwater management, the criteria that produces the largest storage volume should be used to size the basin. The discharge structure should be designed as a permanent stormwater facility with respect to its riser and barrel hydraulics and materials. The riser's geometry may then be temporarily modified to provide the wet and dry storage for the temporary sediment basin, as required by VESCH, 1992 edition.

Safety

Basins that are readily accessible to populated areas should include all possible safety precautions. Steep side slopes (steeper than 3H:1V) at the perimeter should be avoided and dangerous outlet facilities should be protected by enclosures. Warning signs for temporary deep water conditions and potential health risks should be used wherever appropriate. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths. A dry basin may hold a significant amount of soft sediment in the bottom, posing a danger to small children.

A fence is required at or above the maximum water surface elevation when a basin slope is a vertical wall. Local governments and homeowners associations may also require appropriate fencing despite the steepness of the basin side slopes.

Maintenance

Extended-detention basins have shown an ability to function as designed for long periods without routine maintenance. However, some maintenance is essential to protect the aesthetic properties of these facilities.

Vehicular access to the sediment forebay and the release structure should be provided to allow for long-term maintenance (such as sediment removal) and repairs, as needed. The use of a sediment forebay at the upstream end of the basin will help to localize the disturbance during routine sediment removal operations. An onsite area designated for sediment dewatering and disposal should also be included in the design. Care must be taken in the disposal of sediment that may contain an accumulation of heavy metals. **Sediment testing is recommended prior to sediment removal to assure proper disposal**.

A sign should be posted near the basin that clearly identifies the person or organization responsible for basin maintenance. Allowing participation by adjacent landowners or visitors is very helpful, especially if the facility is used for recreation. Maintenance items observed and addressed early will

help to limit overall maintenance costs. Routine maintenance inspections, however, should be conducted by authorized personnel
.

Design Criteria

This section provides recommendations and minimum criteria for the design of extended-detention and *enhanced* extended-detention basins intended to comply with the Virginia Stormwater Management program. It is the designer's responsibility to decide which aspects of the program are applicable to the particular facility being designed and to decide if any additional design elements are required. The designer should also consider the long-term functioning of the facility when selecting materials for the structural components.

Hydrology and Hydraulics

The pre- and post-developed hydrology for a basin's contributing watershed, the hydraulic analysis of the riser and barrel system, and the emergency spillway design should be developed using **Chapter 4, Hydrologic Methods** and **Chapter 5, Engineering Calculations**.

Generally, the 2-year storm should be used in *receiving channel adequacy* calculations and the 10-year storm should be used for *flood control* calculations. Alternate requirements, such as 1-year extended detention for channel erosion control may be imposed by local ordinances.

Embankment

The design of the earthen embankment for an extended-detention and *enhanced* extended-detention basin should comply with **Minimum Standard 3.01, Earthen Embankment**. The requirements for geotechnical, seepage control, maximum slope, and freeboard are particularly appropriate.

Principal Spillway

The design of the principal spillway and barrel system, anti-vortex device, and trash racks should comply with **Minimum Standard 3.02, Principal Spillway**.

<u>Emergency Spillway</u>

An emergency spillway that complies with **Minimum Standard 3.03, Vegetated Emergency Spillway** should be provided when possible, or appropriate.

<u>Sediment Basin Conversion</u>

When a proposed stormwater facility is used initially as a temporary sediment basin, conversion to the permanent facility should be completed after final stabilization and approval from the appropriate erosion and sediment control authority.

Sometimes, the temporary sediment basin design criteria will require more storage volume than that of a stormwater basin. In such cases, the extra volume may be allocated to the component of the facility that would derive the greatest benefit from increased storage. This will depend on the primary function of the facility (i.e., water quality enhancement, flood control, or channel erosion control).

If modifications to the riser structure are required as part of the conversion to a permanent basin, they should be designed so that a) *the structural integrity of the riser is not threatened*, and b) *large construction equipment is not needed within the basin*. Any heavy construction work required on the riser should be completed during its initial installation. It is **<u>NOT</u>** recommended to install a temporary sediment basin riser structure in the basin and then replace it with a permanent riser after final stabilization. This may affect the structural integrity of the existing embankment and barrel.

The following additional criteria should be considered for a conversion:

1. Final elevations and a complete description of any modifications to the riser structure geometry should be shown on the approved plans.

2. The wet storage area must be dewatered following the approved methods in <u>VESCH</u>, 1992 edition.

3. Sediment and other debris should be removed to a contained spoil area. Regrading of the basin may be necessary to achieve the final design grades and to provide an adequate topsoil layer to promote final stabilization.

4. Final modifications to the riser structure should be carefully inspected for water tight connections and compliance with the approved plans.

5. Final landscaping and stabilization should be per <u>VESCH</u>, 1992 edition, and **Minimum Standard 3.05, Landscaping** in this manual. Establishing vegetation may prove difficult if flow is routed through the facility prior to germination. In such cases, specifying sod or other reinforcements for the basin bottom and low flow channels may be appropriate.

Extended-Detention Volume

Water quality extended-detention basins are designed to allow particulate pollutants to settle out of water quality volume. **Chapter 5, Engineering Calculations** provides calculation procedures for determining the *water quality volume* for a particular watershed, and for sizing the release orifice to provide the required 30-hour draw down. **The water quality volume is the first one-half inch of runoff from the impervious surfaces**.

Channel erosion control extended-detention basins are designed to reduce the rate of discharge such that the velocity is below the critical velocity for the downstream channel. **Chapter 5, Engineering Calculations** provides the calculation procedures for calculating the *channel erosion control volume* for a particular watershed, and for sizing the release structure to provide the required 24-hour draw down. **The channel erosion control volume is the runoff generated from the drainage area or watershed by the 1-year frequency design storm.**

The orifice sizing procedure for extended detention is based on a "*brim*" drawdown. The full design volume is assumed to be in the basin, and the drawdown period is the time it takes to drain that entire volume. In reality, this technique ignores the *routing effect* that occurs in the basin: as the runoff volume accumulates, stormwater is draining into the basin while simultaneously draining out of it. For small storms, the extended-detention volume will never fill to the "brim" and will, therefore, never achieve the maximum drawdown time.

The calculation procedure used to verify the draw down time is presented in **Chapter 5.** The extended-detention volume (in cubic feet) is divided by the maximum release rate (in cubic feet per second), which is based on the maximum hydraulic head associated with the water quality volume, to give the *detention time*, in seconds. Using the maximum release rate, rather than the average release rate, results in a smaller orifice, which helps to compensate for ignoring the routing effect, as discussed above.

Enhanced Extended-Detention Basin: Shallow Marsh

When a higher pollutant removal efficiency is needed, a water quality extended-detention basin can be enhanced by providing a *shallow marsh* in the bottom of the facility. The use of a shallow marsh limits the maximum range of vertical storage in the extended-detention pool to 3 feet above the marsh's water surface elevation. However, the surface area requirements for the shallow marsh will likely force the basin's geometry to broaden at the lower stages, which will compensate for the reduced vertical storage. Extended-detention water surface elevations greater than 3 feet, and the frequency at which those elevations can be expected, are not conducive to the growth of dense or diverse stands of emergent wetland plants.

Similar to the permanent pool of a constructed wetland, the shallow marsh in the bottom of an extended-detention basin should be designed to maximize pollutant removal efficiency. The physical and hydraulic factors that can influence the pollutant removal efficiency of a shallow marsh are: 1) *volume*, 2) *depth*, 3) *surface area*, 4) *geometry*, and 5) *hydraulic residence time*. In addition, careful attention should be given to the landscaping plan (refer to **Minimum Standard 3.09, Constructed Wetland** for design criteria regarding the establishment of vegetation in a shallow marsh.

The following criteria are general guidelines. The depth of the treatment volume and amount of surface area varies with each site and the intended secondary functions of the facility (i.e., providing habitat, aesthetics, etc.).

1. **Volume–**

The pool volume of an extended-detention shallow marsh varies with the water quality volume. The water quality volume (WQV), as defined by Virginia Stormwater Management regulations, is the **first one-half inch of runoff, multiplied by the area of impervious surface**. The target pollutant removal efficiency of an *enhanced* extended-detention basin, as presented in **Table 3.07-1**, is based on 2.0 times the WQV. The shallow marsh pool volume represents 1.0 × WQV and the extended-detention volume represents an additional 1.0 × WQV. The pollutant removal efficiency is directly related to the percentage of runoff available to be treated. If it is assumed that all of the rainfall that hits impervious surfaces turns into runoff (ignoring minor losses such as evaporation, depression storage, etc.), then a design volume of 2.0 × WQV represents a design storm of 1 inch of rainfall. Based upon available rainfall data from the Washington, D.C. area, 1 inch of rainfall represents approximately 85% of all runoff producing storm events (MWCOG, 1992). Therefore, 2.0 × WQV (or 1 inch of rainfall from impervious surfaces) represents a significant percentage of runoff producing events.

2. **Depth–**

The treatment volume of a shallow marsh should occupy different depth zones, as shown in **Table 3.07-2**, to maximize the physical and biological processes that occur within the marsh. Three basic depth zones should be used: a) *deep pools*, b) *low-marsh*, and c) *high-marsh*.

a. Deep pool areas should be 1.5 to 4 feet deep and may consist of 1) *sediment forebays*, 2) *micro-pools*, and 3) *deep water channels*.

   1. A sediment forebay is highly recommended in a shallow marsh. It should be constructed near incoming pipes or channels to reduce the velocity of incoming runoff, trap course sediments, and spread the runoff evenly over the marsh area. The forebay should be constructed as a separate cell from the rest of the marsh, with maintenance access provided to simplify cleaning with heavy equipment (refer to **Minimum Standard 3.04, Sediment Forebay**).

   2. A micro-pool should be a standard component of the extended-detention shallow marsh. The purpose of a micro-pool is to create sufficient depth near

the outlet to help reduce clogging of the extended detention orifice. This will allow for a reverse-sloped pipe to extend into the marsh below the pool surface elevation but above the pool bottom which helps to prevent clogging, since a typical marsh environment consists of floating plant debris and possible sediment and organic accumulation on the bottom. Micro-pools also provide open water areas to attract plant and wildlife diversity (refer to the **Overflow** discussion later in this section).

3. Deep water channels provide an opportunity to lengthen the flow path to avoid seasonal short-circuiting (refer to the **Geometry** discussion later in this standard.)

b. Low-marsh zones range in depth from 6 to 18 inches.

c. High-marsh zones range in depth from 0 to 6 inches. The high-marsh zone will typically support the greatest density and diversity of emergent plant species.

3. **Surface Area–**

At a minimum, the surface area of an extended-detention shallow marsh should be sized to equal 1% of the contributing drainage area. The recommended surface area allocation for the different depth zones is presented in **Table 3.07-2** (MWCOG, 1992). Note that the surface area criteria may create a conflict with the volume allocations. If this happens, the designer is reminded that these are recommendations. **The criteria that establish the largest permanent pool should be used**.

4. **Geometry–**

The geometry of the shallow marsh must be carefully designed to avoid *short-circuiting*. Meandering, rather than straight line flow is desirable. Maximum pollutant removal efficiencies will be achieved due to the increased contact time associated with the longest possible flow path through the marsh. A length-to-width ratio of 2:1 through the marsh should be maintained (see **Figure 3.07-4**). The length-to-width ratio is calculated by dividing the straight line distance from the inlet to the outlet by the marsh's average width.

TABLE 3.07 - 2
Recommended Allocation of Surface Area and Treatment Volume for Depth Zones

Depth Zone	% of Surface Area	% of Treatment Volume
Deep Water 1.5 to 4 feet in depth (forebay and micro-pool)	20	40
Low Marsh 0.5 to 1.5 feet in depth	40	40
High Marsh 0 to 0.5 feet	40	20

(Adapted from MWCOG, 1992)

5. **Hydraulic Residence Time–**

The *hydraulic residence time* is the shallow marsh pool volume divided by the average outflow discharge rate. The longer the residence time, the higher the pollutant removal efficiency (Driscoll, 1983, Kulzer, 1989).

In theory, by using 1.0 x WQV in sizing the shallow marsh volume, the smaller storms (those producing ½ inch of runoff or less) will displace the pool volume of the marsh. However, larger treatment volumes (such as 2 or 3 x WQV), compared with the watershed size, will provide longer residence times and greater efficiencies. In certain situations, increasing the target pollutant removal efficiency by using a higher water quality volume multiplier to size the marsh volume may be acceptable. However, the challenge will be to provide the recommended depth zone allocations for the allocated percentages of surface area and treatment volumes, as previously discussed.

Base Flow

The presence of a *base flow* makes the design of an extended-detention control structure difficult. If the extended-detention orifice is sized for the *wet weather base flow*, then the dry weather control is compromised because the release rate is too high. If the orifice is undersized to maintain the *dry weather control*, then the extended-detention pool may remain full of water during the wet weather season; this essentially eliminates the extended-detention volume by creating an undersized permanent pool (1.0 x WQV). When seasonal base flow is present, an adjustable orifice should be provided in the control structure to maintain the marsh volume.

The presence of a base flow and the associated potential for erosion within the basin should be considered in the design. Ideally, base flow, or *low flows*, should be spread out so that they *sheet flow* across the bottom of the basin. Due to maintenance difficulties and undesirable insect breeding associated with standing water, some localities may have ordinances that require *low-flow channels* (or *trickle ditches*) to carry base flows. If an *impervious* ditch is used to convey base flows, it should be designed to overflow during storm events and spread the runoff across the basin floor. The use of gabion baskets or riprap, instead of concrete, may provide the advantage of slowing the flow, encouraging spillover onto the basin floor. **Generally, an impervious low-flow channel is NOT recommended in a stormwater management water quality basin, as its use is contrary to the basin's water quality function**.

Local ordinances should be reviewed for specific requirements relating to low-flow or base-flow channels in dry detention basins.

Overflow

Similar to a constructed stormwater wetland, an extended-detention overflow system should be designed to provide adequate overflow or bypass for a full range of design storms. For an *enhanced* extended-detention basin, the overflow system should pass the full range of design storms with no more than 3 feet of hydraulic head above the shallow marsh.

Sediment Forebay

A sediment forebay will help to postpone overall basin maintenance by trapping incoming sediments at a specified location. The forebay should be situated and designed per **Minimum Standard 3.04, Sediment Forebay**. Usually, a sediment forebay is placed at the outfall of the incoming storm drain pipes and positioned to ensure access for maintenance equipment.

A sediment forebay enhances the pollutant removal efficiency of a basin by trapping the incoming sediment load in one area where it can be easily monitored and removed. For an *enhanced* extended-detention basin, the sediment forebay is included in the deep pool allocations of the surface area and storage volume. The target pollutant removal efficiency of an extended-detention basin, as listed in **Table 3.07-1**, is predicated on using a sediment forebay at the inflow points of the basin.

Liner to Prevent Infiltration

Extended-detention basins should have negligible infiltration rates through the bottom of the basin. Infiltration will impair the proper functioning of the basin and may contaminate groundwater, and in areas of Karst, may cause collapse. For an *enhanced* extended-detention basin, excessive infiltration may prevent the shallow marsh from holding water. If infiltration is anticipated, and the area is not suspected to be underlain by Karst, than an infiltration facility, rather than a detention water quality BMP, should be used **or** a liner should be installed in the basin to prevent infiltration.

When using a liner, the following recommendations apply:

1. A clay liner should have a minimum thickness of 12 inches and should comply with the specifications provided in **Table 3.07-3**.

2. A layer of compacted topsoil (minimum 6 to 12 inches thick) should be placed over the liner before seeding with an appropriate seed mixture (refer to VESCH, 1992 edition)

3. Other liner types may be used if supporting documentation is provided verifying the liner material's performance.

TABLE 3.07 - 3
Clay Liner Specifications

Property	Test Method (or equal)	Unit	Specification
Permeability	ASTM D-2434	*cm/sec*	1×10^{-6}
Plasticity Index of Clay	ASTM D-423 & D-424	%	Not less than 15
Liquid Limit of Clay	ASTM D-2216	%	Not less than 30
Clay Particles Passing	ASTM D-422	%	Not less than 30
Clay Compaction	ASTM D-2216	%	95% of Standard Proctor Density

Source: City of Austin, 1988

Access

A 10 to 12 foot wide access road with a maximum grade of 12% should be provided to allow vehicular access to both the outlet structure area and at least one side of the basin. The road's surface material should be selected to support the anticipated frequency of use and vehicular load without excessive erosion or damage.

Landscaping

A qualified individual should prepare the landscape plan for an extended-detention basin. Appropriate shoreline fringe, riparian fringe and floodplain terrace vegetation must be selected to correspond with the expected frequency and duration of inundation. Additional criteria for landscaping may be found in **Minimum Standard 3.05, Landscaping**. For establishment of vegetation in the marsh area, refer to **Minimum Standard 3.09, Constructed Wetland**.

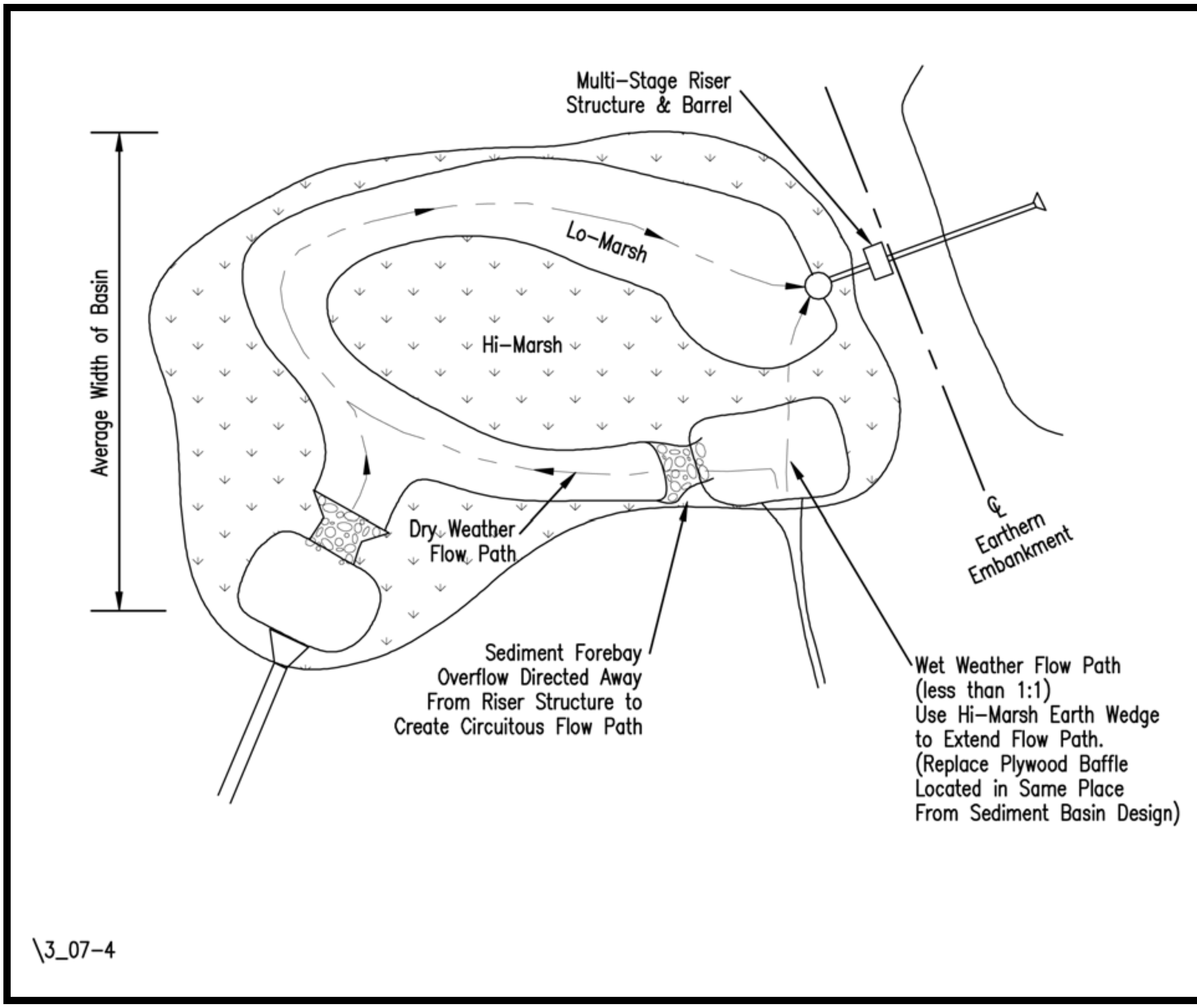
The vegetation should be planted in soil that is appropriate for the plants selected. Soil tests showing the adequacy of the soil or a soil enhancement plan should be submitted with the overall basin design.

The soil substrate must be soft enough to permit easy installation of the plants. If the basin soil has been compacted or vegetation has formed a dense root mat, the upper 6 inches of soil should be disked before planting. If soil is imported, it should be laid at least 6 inches deep to provide sufficient depth for plant rooting to occur.

Buffer Zone

A vegetated buffer strip should be maintained beside the basin. The strip should be a minimum of 20 feet wide, as measured from the maximum water surface elevation. Refer to **Minimum Standard 3.05, Landscaping**.

FIGURE 3.07 - 4
Flow Path/Short-Circuiting



Construction Specifications

The construction specifications for stormwater extended-detention and *enhanced* extended-detention basins outlined below should be considered minimum guidelines. More stringent or additional specifications may be required based on individual site conditions.

Overall, widely accepted construction standards and specifications for embankment ponds, such as those developed by the USDA Soil Conservation Service or the U.S. Army Corps of Engineers, should be followed to build an impoundment.

Further guidance can be found in Chapter 17 of the Soil Conservation Service's Engineering Field Manual. Specifications for the work should conform to methods and procedures specified for installing earthwork, concrete, reinforcing steel, pipe, water gates, metal work, woodwork and masonry and any other items that apply to the site and the purpose of the structure. The specifications should also satisfy any requirements of the local plan approving authority.

The following minimum standards contain guidance and construction specifications for various components of these facilities: **3.01, Earthen Embankment**; **3.02, Principal Spillway**; **3.03, Vegetated Emergency Spillway**; **3.04, Sediment Forebay**; **3.05, Landscaping**, and **3:09, Constructed Wetland**.

Maintenance and Inspections

The following maintenance
and inspection guidelines are not intended to be all-inclusive. Specific facilities may require other measures not discussed here. The engineer is responsible for determining if any additional items are necessary.

Inspecting and maintaining the structures and the impoundment area should be the responsibility of the local government, a designated group such as a homeowner association, or an individual. A specific maintenance plan should be formulated outlining the schedule and scope of maintenance operations.

General Maintenance

Maintenance and inspection guidelines found in the following minimum standards also apply: **3.01, Earthen Embankment**; **3.02, Principal Spillway**; **3.03, Vegetated Emergency Spillway**; **3.04, Sediment Forebay**, and **3.05, Landscaping**.

Vegetation

The basin's side slopes, embankment and emergency spillway should be mowed at least twice a year to discourage woody growth. More frequent mowing may be necessary in residential areas for aesthetic purposes.

Dry extended-detention basins may have soggy bottoms, making mowing costly and difficult. The use of water-tolerant, hardy, and slow growing grass is recommended for the bottom of these basins. **Vegetation is preferred to an impervious low-flow channel since the channel may interfere with the pollution removal capabilities of the basin**. The designer should be aware of local program requirements, as some localities require low-flow channels.

Specific plant communities may require different levels of maintenance. Upland and floodplain terrace areas, grown as meadows or forests, require very little maintenance, while aquatic or emergent vegetation may need periodic thinning or reinforcement plantings. Note that after the first growing season it should be obvious if reinforcement plantings are needed. If they are, they should be installed at the onset of the second growing season after construction.

Research indicates that for most aquatic plants the uptake of pollutants is stored in the roots, not the stems and leaves (Lepp 1981). Therefore, aquatic plants should not require harvesting before winter plant die-back. There are still many unanswered questions about the long term pollutant storage capacity of plants. Possible aquatic and emergent plant maintenance recommendations may be presented in the future.

Debris and Litter Removal

Debris and litter will accumulate near the inflow points and around the outlet control structure. Such material should be removed periodically. Significant accumulation can clog the low-flow outlet and the upper control openings.

Sediment Removal

Sediment deposition should be continually monitored in the basin. Removal of accumulated sediment is extremely important. A significant accumulation of sediment impairs the pollutant removal capabilities of the basin by reducing the available storage for the water quality volume and/or reducing the available volume for the shallow marsh. In addition, accumulated sediment in the bottom of a basin creates unsightly conditions and chokes out established vegetation.

Unless unusual conditions exist, it is anticipated that accumulated sediment will need to be removed from the basin every 5 to 10 years (MWCOG, 1987). More frequent cleaning of the area around the low flow or extended-detention orifice may be required. The use of a sediment forebay with access for heavy equipment will greatly simplify the removal process. **During maintenance procedures,**

ensure that any pumping of standing water or dewatering of dredged sediments complies with the VESCH, 1992 edition, and any local requirements.

Owners, operators, and maintenance authorities should be aware that significant concentrations of heavy metals (e.g., lead, zinc and cadmium) and some organics, such as pesticides, may be expected to accumulate at the bottom of a basin. Testing of sediment, especially near points of inflow, should be conducted regularly and **before disposal** to find the leaching potential and level of accumulation of hazardous materials. Disposal methods must comply with the health department requirements of the local government.

Inspections

An extended-detention basin and its components should be inspected annually to ensure that they operate in the manner originally intended. If possible, inspections should be conducted during wet weather to determine if the extended-detention time is being achieved. Inspections should be conducted by a qualified individual following the checklist provided in **Chapter 3 Appendix**.

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Extended Detention Basin – full. Note circuitous flow path.

Enhanced Extended Detention Basin – Shallow Marsh. Note multi-stage weir principal spillway and deep water pool (18” – 48” depth).

Extended-Detention Basin & Enhanced Extended-Detention Basin

Extended Detention Basin – empty.

Extended Detention Basin – full.

Extended-Detention Basin & Enhanced Extended-Detention Basin